PB-240 518

MALMEDAL LAKE, POPE COUNTY, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota Pollution Control Agency
Minnesota National Guard

October 1974

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NATIONAL EUTROPHICATION SURVEY

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT

ON

MALMEDAL LAKE

POPE COUNTY

MINNESOTA

EPA REGION V

WORKING PAPER No. 109

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

OCTOBER, 1974

II

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

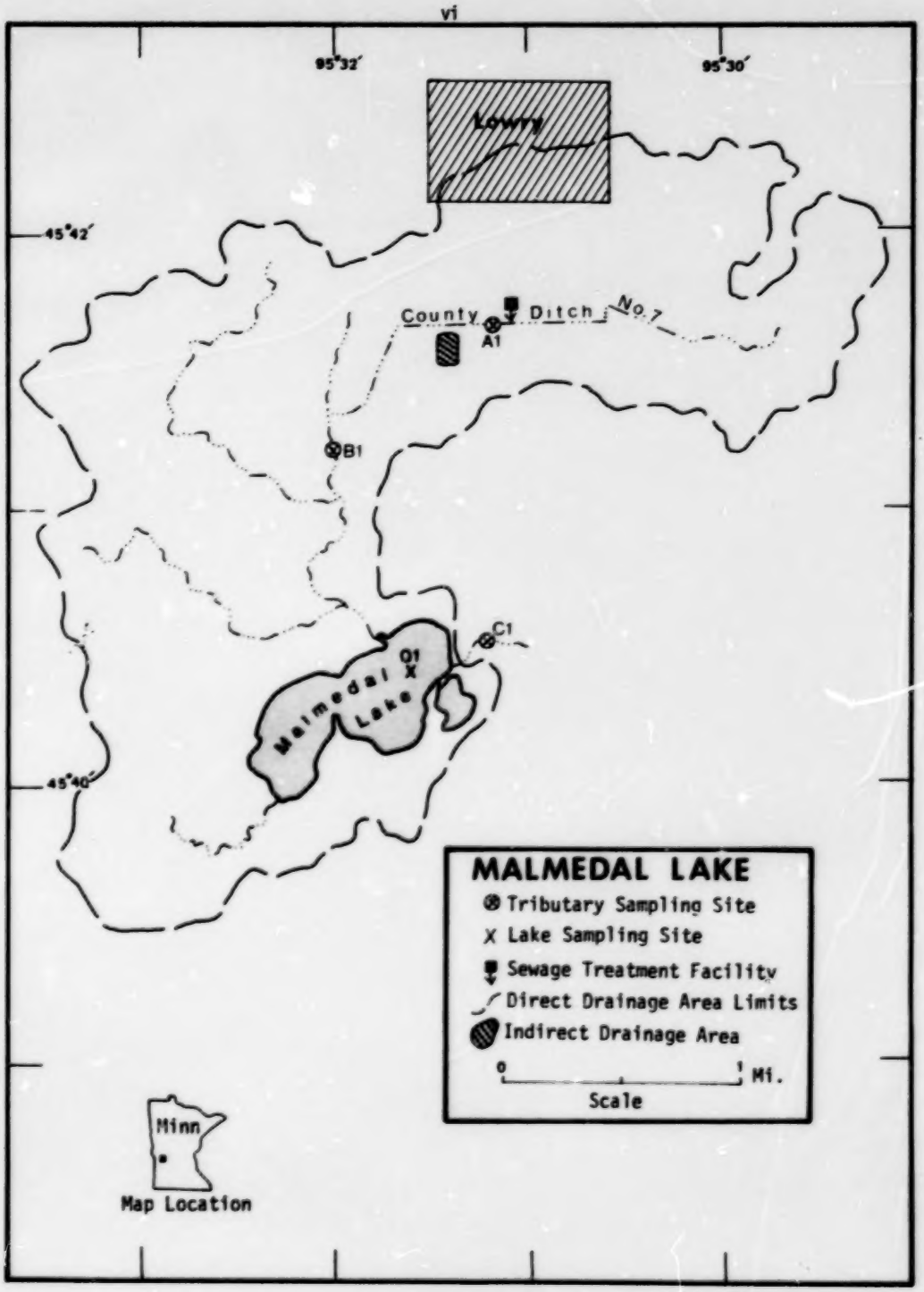
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatan	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


95°32'
95°30'
45°42'
45°40'
Lowry
County Ditch No 7
A1
B1
C1
Q1
Malmedal Lake
MALMEDAL LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Direct Drainage Area Limits
Indirect Drainage Area
0
1
Mi.
Scale
Minn
Map Location

MALMEDAL LAKE

STORET NO. 2752

I. CONCLUSIONS

A. Trophic Condition:

It is concluded that Malmedal Lake is eutrophic. Survey limnologists noted the prevalence of rooted aquatic vegetation and extreme turbidity.

Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 33 had less mean total phosphorus and 41 had less mean inorganic nitrogen. For all 80 lakes sampled, 84% had greater transparency, and 75% had less mean chlorophyll a.

B. Rate-Limiting Nutrient:

The algal assay results show that Malmedal Lake was phosphorus limited at the time the sample was collected, but the lake data indicate nitrogen limitation in July and September, 1972.

C. Nutrient Controllability:

Because of the estimations and assumptions made in the assessment of loading rates, it is not realistic to make further estimations and assumptions as to loading rates or nutrient controllability, particularly in view of the fact that during the sampling year the amount of phosphorus measured leaving the lake was 1.5 times the estimated total load to the lake.

It appears there may have been some mislabeled samples from the tributaries. The mean total phosphorus in the inlet stream, below the Lowry wastewater pond was about 0.19 mg/l but the mean total phosphorus in the outlet of the lake was over 0.25 mg/l (note that the total P concentration in the October, 1972, outlet sample was nearly two times the P concentration measured in the lake at about the same time).

Now, phosphorus wash-out could have occurred, particularly if point-source contributions had been reduced or eliminated recently; however, as far as is known, no such reduction occurred.

A need for a more detailed study of the Malmedal Lake system is indicated.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry*:

1. Surface area: 195 acres.
2. Mean depth: 6** feet.
3. Maximum depth: 8 feet.
4. Volume: 1,170 acre/feet.
5. Mean hydraulic retention time: 1.3 years.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area†	Mean flow†
County Ditch No. 7	4.2 mi^2	0.6 cfs
Minor tributaries & immediate drainage -	3.8 mi^2	0.6 cfs
Totals	8.0 mi^2	1.2 cfs

2. Outlet -

Unnamed Stream	8.3 mi^{2}††	1.2 cfs

C. Precipitation†††:

1. Year of sampling: 24.8 inches.
2. Mean annual: 17.9 inches.

---

* DNR lake survey map (1971).
** Anonymous, 1972.
† Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
†† Includes area of lake.
††† See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Malmedal Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two depths at one station on the lake (see map, page vi). During each visit, a single depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was collected for algal assays. Also each time, a depth-integrated sample was collected for chlorophyll a analysis. The maximum depth sampled was 4 feet.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/25/72)		
Temperature (Cent.)	4.4	4.4	4.4	4.4
Dissolved oxygen (mg/l)	12.4	12.4	12.4	12.4
Conductivity (μmhos)	600	600	600	600
pH (units)	8.7	8.7	8.7	8.7
Alkalinity (mg/l)	180	180	180	180
Total P (mg/l)	0.060	0.062	0.062	0.065
Dissolved P (mg/l)	0.021	0.023	0.023	0.025
NO_2 + NO_3 (mg/l)	0.100	0.105	0.105	0.110
Ammonia (mg/l)	0.330	0.330	0.330	0.330
		ALL VALUES		
Secchi disc (inches)	13	15	15	16

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/06/72	1. Microcystis	2,651
	2. Oscillatoria	2,440
	3. Closterium	2,199
	4. Melosira	1,566
	5. Cyclotella	1,084
	Other genera	6,385
	Total	16,325
09/01/72	1. Melosira	16,061
	2. Microcystis	11,364
	3. Lyngbya	4,848
	4. Oscillatoria	4,545
	5. Flagellates	4,394
	Other genera	16,212
	Total	57,424
10/25/72	1. Oscillatoria	1,973
	2. Anabaena	1,732
	3. Microcystis	1,611
	4. Dinobryon	422
	5. Lyngbya	271
	Other genera	2,093
	Total	8,102

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
07/06/72	01	49.8
09/01/72	01	63.5
10/25/72	01	9.7

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.014	0.376	7.4
0.005 P	0.019	0.376	8.5
0.010 P	0.024	0.376	9.2
0.020 P	0.034	0.376	9.3
0.050 P	0.064	0.376	9.9
0.050 P + 10.0 N	0.064	10.376	29.8
10.0 N	0.014	10.376	6.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that Malmedal Lake had a high level of potential primary productivity at the time the sample was collected. Also, the increased yields with increased levels of orthophosphorus (up to about 0.024 mg/l) show that the lake was phosphorus limited. Note that addition of only nitrogen resulted in a yield not significantly different from the control yield.

The lake data also indicate phosphorus limitation in October (N/P ratio of 19/1) but nitrogen limitation in July and September (N/P ratios of 4/1 and 10/1, respectively).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May, when two samples were collected, and the colder months of the year when ice cover prevented sampling. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean concentrations and the mean monthly flows for the sampling year.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient loads, in lbs/mi^2/year, in Fish and three unnamed creeks tributary to nearby Big Stone Lake (see Working Paper No. 85) at stations 2709G-1, D-1, E-1, and F-1 (19 lbs P and 369 lbs N/mi^2/yr) and multiplying the means by the Malmedal Lake ZZ area in mi^2.

During the sampling year, the phosphorus load measured in County Ditch No. 7 at station B-1 was 380 lbs. This is less than the amount that would have been estimated for the Village of Lowry on a per-capita

basis (1970 Census = 257 x 2.5 lbs P/capita/yr = 640 lbs P/yr.) Therefore, in the loading tables that follow, the phosphorus load attributed to Lowry is the load measured at station B-1 minus the estimated non-point source load of 19 lbs P/mi^2/yr (4.2 mi^2 x 19 = 80 lbs).

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Lowry	257*	Pond	0.026**	County Ditch #7

2. Known industrial - None

* 1970 Census.
** Estimated at 100 gal/capita/day.

B. Annual Total Phosphorus Loading - Sampling Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
County Ditch No. 7	80	16.7
b. Minor tributaries & immediate drainage (non-point load) -	70	14.6
c. Known municipal -		
Lowry	300	62.5
d. Septic tanks - None known	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	30	6.2
Total	480	100.0

2. Outputs -

Lake outlet 1,200

3. Net annual P loss - 720 pounds

* See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Sampling Year:

1. Inputs -

Source	lbs N/yr	% of total
a. Tributaries (non-point load) -		
County Ditch No. 7	4,270	50.2
b. Minor tributaries & immediate drainage (non-point load) -	1,400	14.9
c. Known municipal -		
Lowry	930	11.2
d. Septic tanks - None known	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	1,890	22.7
Total	8,490	100.0

2. Outputs -

Lake outlet 7,350

3. Net annual N accumulation - 1,140 pounds

* See Working Paper No. 1.

V. LITERATURE REVIEWED

Anonymous, 1972. Survey questionnaire. MPCA, Minneapolis.

Anonymous, 1973. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Schilling, Joel, 1974. Personal communication (lake map). MPCA, Minneapolis.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2762 PALMDALE LAKE

TOTAL DRAINAGE AREA OF LAKE = 8.29

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
275241	0.17	0.03	0.03	0.73	1.66	1.24	1.15	0.75	0.35	0.70	0.27	0.15	0.14	0.62
2752C1	0.20	0.14	0.06	1.22	3.49	2.58	2.70	1.51	0.75	1.34	0.56	0.35	0.26	1.24
275277	4.12	0.05	0.01	0.40	1.62	1.27	1.15	0.77	0.36	0.73	0.28	0.17	0.14	0.62

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 8.29
SUM OF SUB-DRAINAGE AREAS = 8.29

TOTAL FLOW IN = 14.82
TOTAL FLOW OUT = 14.83

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
275241	11	72	0.71	15	0.40				
	11	72	0.44	10	0.60				
	12	72	0.0	0	0.0				
	1	73	0.24	7	0.0				
	2	73	0.14	4	0.20				
	3	73	1.20	16	2.10				
	4	73	1.61	15	1.60	30	1.20		
	5	73	1.34	30	0.90	30	1.20		
	6	73	0.67	11	0.70				
	7	73	0.23	17	0.14				
	8	73	0.24	7	0.14				
	9	73	0.65	10	0.65				
2752C1	10	72	1.33	15	2.00				
	11	72	1.27	15	1.60				
	12	72	1.63	4	1.40				
	1	73	0.59	7	0.60				
	2	73	0.37	4	0.30				
	3	73	4.33	16	4.50				
	4	73	4.36	15	4.10	30	4.10		
	5	73	3.31	20	2.40	30	3.20		
	6	73	1.65	11	1.40				
	7	73	0.59	17	0.40				
	8	73	0.64	7	0.47				
	9	73	1.68	10	1.10				
275277	10	72	0.77	15	0.40				
	11	72	0.44	10	0.60				
	12	72	0.03	4	0.40				
	1	73	0.24	7	0.30				
	2	73	0.15	4	0.20				
	3	73	1.24	16	1.80				
	4	73	1.67	15	1.50	30	1.10		
	5	73	1.40	30	1.01	30	1.30		
	6	73	0.66	11	0.70				
	7	73	0.30	17	0.14				
	8	73	0.25	7	0.14				
	9	73	0.67	10	0.67				

15

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

275201
45 40 25.0 095 31 38.0
MALMEDAL LAKE
27 MINNESOTA

11EPALES
3

2111202
0006 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/06	16 20	0000	21.0	11.0	16	520	8.10	188	0.040	0.060	0.147	0.027
	16 20	0002	21.0	5.4		520	8.00	193	0.040	0.120	0.209	0.034
72/09/01	15 10	0000	20.0		13	550	8.40	157	0.140	0.220	0.134	0.040
	15 10	0004	19.9	11.7		575	8.30	155	0.150	0.280	0.117	0.038
72/10/25	14 30	0000				600	8.70	180	0.110	0.330	0.060	0.021
	14 30	0004	4.4	12.4		600	8.70	180	0.100	0.330	0.065	0.025

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/06	16 20	0000	49.8J
72/09/01	15 10	0000	63.5J
72/10/25	14 30	0000	9.7J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 73/10/10

275281 LS275281
45 41 00.0 095 32 00.0
STRM DRNG TO SWAMP NW EDGE OF LK
27 7.5 LOWRY
T/MALMEDAL LAKE
CO HWY 83 XING HELO LOWRY STP
11EPALES 2111204
" 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 53		1.500	1.555	0.071	0.044	0.064
72/11/10	11 17		1.370	1.540	0.008	0.040	0.066
73/03/10	11 00		3.500	2.400	0.780	0.370	0.410
73/04/15	11 05		1.700	2.200	0.056	0.029	0.050
73/04/30	12 30		2.400	2.510	0.066	0.026	0.040
73/05/20	12 30		2.400	2.100	0.024	0.027	0.040
73/05/30	12 30		2.700	3.200	0.072	0.027	0.045
73/06/11	13 35		4.300	1.890	0.035	0.042	0.055
73/07/17	11 50			2.000	0.051	0.078	0.095
73/09/10	15 02		3.500	4.400	0.042	0.105	1.050

STORET RETRIEVAL DATE 74/10/30

2752C1 LS2752C1
45 40 30.0 095 31 00.0
STRM DRNG SWAMP AT E END OF LAKE
27 7.5 LOWRY
T/MALMEDAL LAKE
ST HWY 114 2 MI S OF LOWRY
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 45		0.230	2.650	0.370	0.014	0.115
72/11/10	11 15		0.156	2.600	0.021	0.030	0.135
73/03/10	10 50		0.310	4.500	2.500	0.380	0.430
73/04/15	11 00		0.049	2.310	0.320	0.017	0.140
73/04/30	12 20		0.025	2.500	0.300	0.030	0.150
73/05/20	12 20		0.027	3.400	0.336	0.028	0.130
73/05/30	12 20		0.030	2.500	0.350	0.030	0.137
73/06/11	13 30		0.038	1.700	0.350	0.056	0.145
73/07/17	11 45			7.500	0.315	0.200	0.690
73/08/07	13 40		0.010K	3.700	1.580	0.210	0.530
73/09/10	14 55		0.026	3.500	0.115	0.043	0.230

K VALUE KNOWN TO BE LESS THAN INDICATED